CHAPTER 11

DAMPENING AND ABSORBING UNITS

HYDRAULIC DAMPERS

Purpose. A damper is a device that controls the speed of relative movement between two connected objects. Usually one end of the damper is connected to a fixed member; the other end, to a movable part. The reacting parts of the damper move against considerable resistance, which slows the speed of relative movement between the objects.

Types. Hydraulic dampers used in Army aircraft operate either by displacing fluid (displacement dampers) or by shearing fluid (shear dampers).

Displacement Dampers. The two types of displacement dampers are the piston type (Figure 11-1) and the vane type (Figure 11-2). Though different in construction, both types have the same basic design characteristics--a sturdy metal container with a sizable inner space divided into two or more chambers. The chambers vary in size according to the position of the parts within the damper. The chambers must be completely filled with fluid to operate properly.

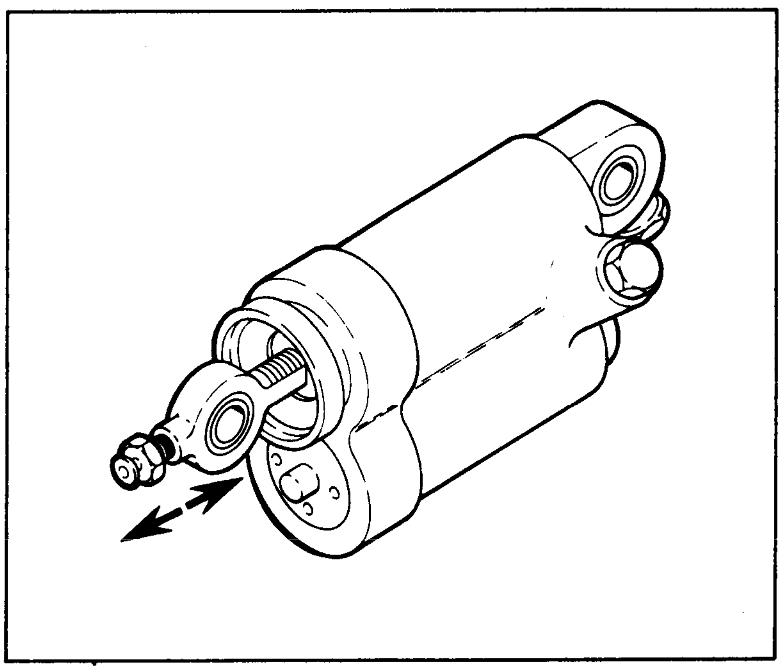

Figure 11-1. Piston-type displacement damper.

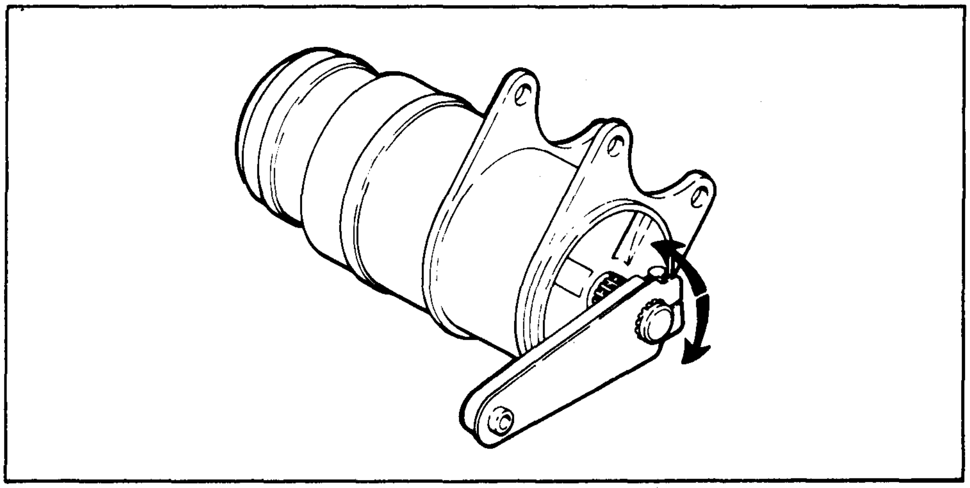

Figure 11-2. Vane-type displacement damper.

Piston-type displacement dampers. In this type damper, the piston and rod assembly divides the space within the damper housing into two chambers. (See Figure 11-3.) Seal rings on the piston prevent fluid leakage between the chambers. An orifice permits fluid to pass with restricted flow from one chamber to the other. A filler port (not shown) services the damper with fluid.

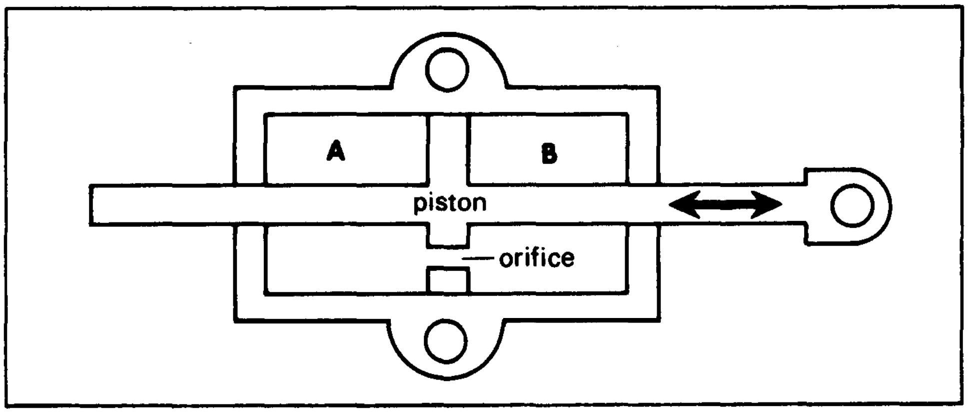

Figure 11-3. Piston-type displacement damper.

As the piston is forced to the right, chamber B decreases in proportion to the distance the piston is moved. Simultaneously, chamber A increases by a comparable size. The hydraulic fluid displaced from chamber B flows through the restricting orifice into chamber A. When the piston is moved toward the left, reverse changes occur in the chamber sizes and in the direction of fluid flow. The restriction of the fluid flow by the orifice slows the rate of speed at which a given amount of force can move the damper piston. The rate at which a damper moves in response to a force is called damping rate or timing rate. In some dampers, the opening is a fixed size, and the timing rate is not adjustable. In other-dampers, the orifice size is adjustable to allow for timing adjustments. The three types of piston dampers are the nose landing gear damper, the tail rotor pedal damper, and the rotor blade damper:

- Nose landing gear damper. The nose landing gear of an aircraft has a tendency to shimmy when the aircraft is taxiing at any appreciable speed. This type damper is used to eliminate wheel shimmy without interfering with the normal steering movements on the nose wheel. (See Figure 11-4.)

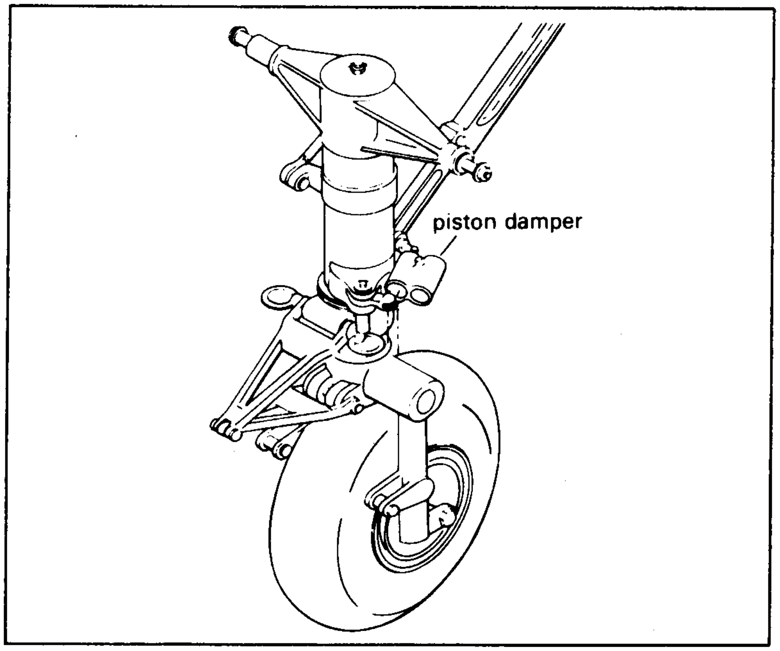

Figure 11-4. Nose landing gear with piston damper.

- Tail rotor pedal damper. Piston-type dampers are used on some helicopters that have power-boosted tail rotor control systems. The dampers are connected to the pedals to prevent rapid pedal movement. (See Figure 11-5.) If the pedals move too rapidly, an excessively fast yaw movement of the aircraft results; this could cause structural damage.

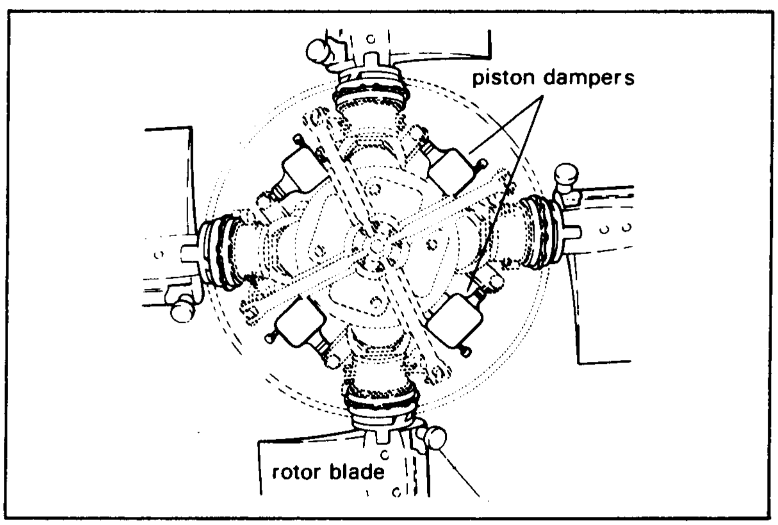

Figure 11-5. Tail rotor assembly with piston dampers.

- Rotor blade damper. Piston-type dampers are used on helicopter rotor head assemblies and tail rotor hub assemblies to control lead-lag movements of rotor blades. Note how the dampers are connected in the illustration at Figure 11-6. Lead-lag movements occur when three or more blades are in a set, and they are hinged to the rotor head.

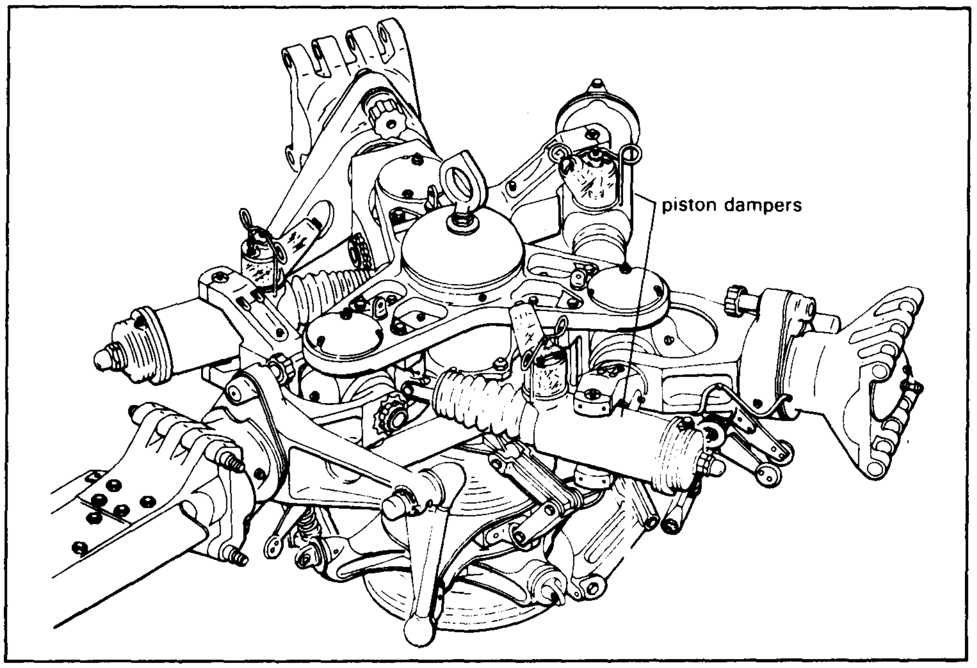

Figure 11-6. Main rotor assembly with piston-type rotor blade dampers.

Vane-type displacement dampers. A typical vane-type damper consists basically of a cylindrical housing having a polished bore with two stationary vanes (called abutments) and a shaft supporting two movable vanes. (See Figure 11-7.) Together, the four vanes split the cylinder bore lengthwise into four chambers. The two stationary vanes are attached to the damper housing. The two movable vanes, along with the shaft, make up a unit called a wing shaft, which rotates between the abutments. One end of the wing shaft is splined and protrudes through the damper housing. A lever arm attached to the splined end rotates the wing shaft.

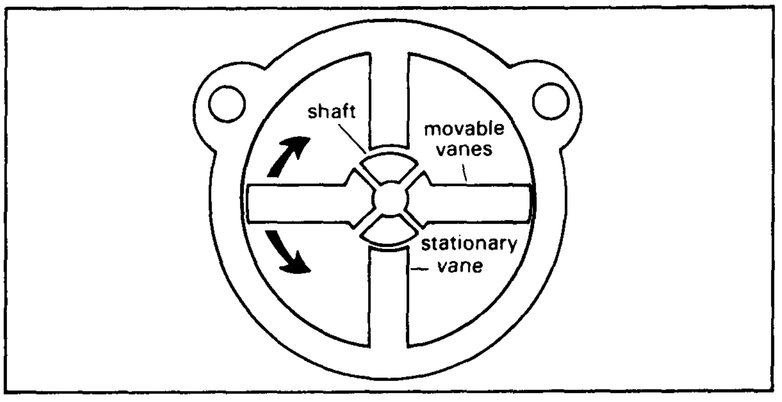

Figure 11-7. Vane-type displacement damper.

The damper chambers are completely filled with fluid. At any instant of damper motion, the fluid is subjected to forced flow. As the wing shaft rotates, fluid between the chambers flows through an opening within the wing shaft, which interconnects the four chambers. Then a restraining force is developed in the damper, dependent on the velocity of fluid flow through the orifice. Slow relative movement between the wing shaft and damper housing causes a low-velocity flow through the opening and little resistance to damper arm rotation. A more rapid motion of the wing shaft increases the speed of fluid flow and thus increases resistance to damper arm rotation. The timing rate of vane-type dampers can be adjusted by a timing adjustment centrally located in the exposed end of the wing shaft. This adjustment sets the effective size of the opening through which fluid flows between chambers; it determines the speed of movement with which the damper will respond to an applied force. The vane-type mechanism is sensitive to changes in fluid viscosity caused by changes in fluid temperature. Most vane-type dampers have a thermostatically operated compensating valve to provide consistent timing rate performance over a wide range of temperatures. The two types of vane-type dampers are the nose landing gear damper and the stabilizer bar damper.

- Nose landing gear damper. A vane-type damper is used on the nose landing gear of some aircraft to eliminate the shimmy tendency. (See Figure 11-8.)

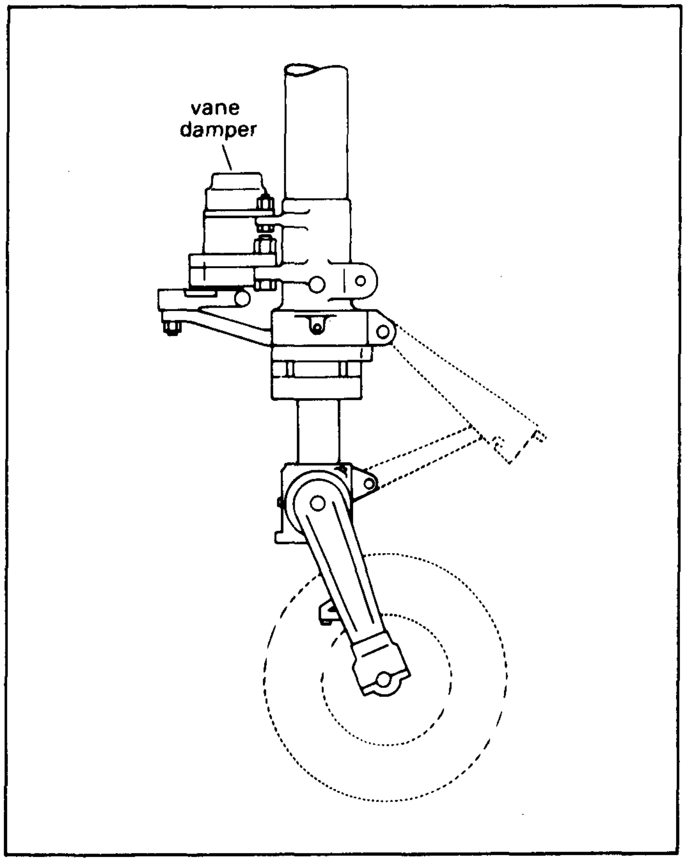

Figure 11-8. Nose landing gear with vane damper.

- Stabilizer bar damper. Some helicopters have vane-type dampers that control the degree of sensitivity with which a helicopter responds to movements made by the pilot on the flight controls. (See Figure 11-9.) These dampers are mounted on a bracket attached to the helicopter mast (main shaft). The damper arms are interconnected with other parts of the flight control system.

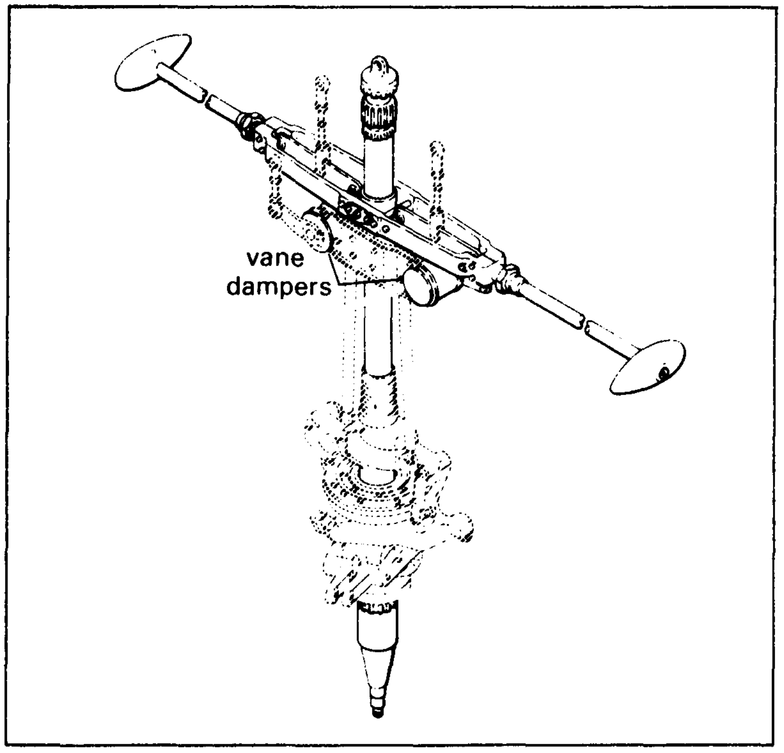

Figure 11-9. Stabilizer bar with vane dampers.

Shear Dampers. In dampers operating on the shear principle, fluid is not forced out of one space and into another space within the damper as it is in displacement dampers. Instead, action on the fluid involves tearing (shearing) a thick film of highly viscous fluid into two thinner films that move with resistance in opposite directions. Highly viscous fluid is thick-bodied, syrupy, and sticky.

In a shear damper, two reacting parts are free to slide or rotate past each other as the damper operates. The surfaces facing each other are relatively smooth; between them is a preset gap of a few thousandths of an inch. This gap is filled with highly viscous fluid. As the parts of the damper move relative to each other, the film of fluid in the gap between them shears into two thinner films. Each film sticks to and moves along with one of the parts. It is the friction within the fluid itself that causes resistance to movement of the parts to which the films stick. To better understand this principle, imagine a puddle of syrup spilled on a relatively smooth table top. A sheet of paper placed on top of the puddle would move with considerable drag. This is very much like what happens between the parts of a shear damper as the damper operates. The two types of shear dampers on Army aircraft are the rotary type and the linear type.

Rotary-type shear damper. A typical rotary-type, shear damper consists of two members that are free to rotate together. (See Figure 11-10.) Each of the members is attached to one of the two objects whose relative movement the damper will restrain.

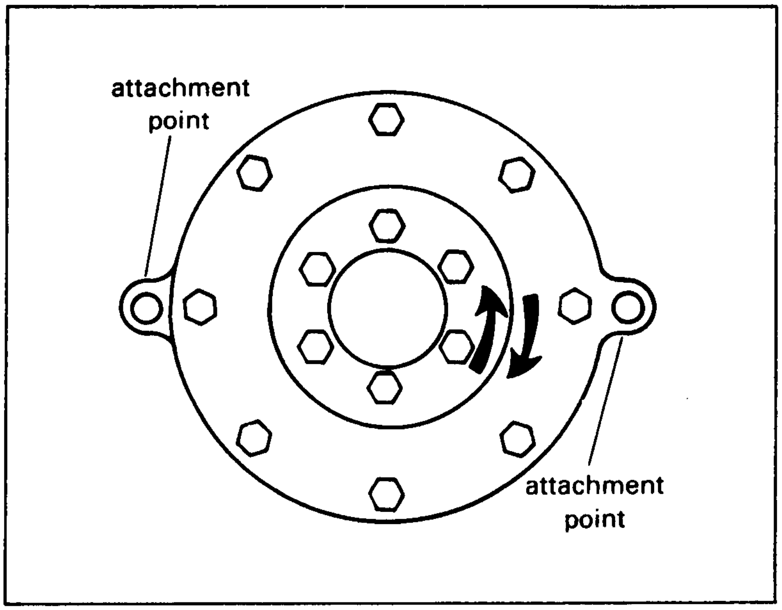

Figure 11-10. Rotary-type shear damper.

One of the damper members has a flange-like section that fits between these two objects. (See Figure 11-11.) Bearing points ensure that the flange is centered between the two surfaces. The spaces between the flange surfaces and the other two surfaces are filled with highly viscous fluid. A spring-loaded piston applies pressure to a supply of replenishment fluid to ensure that the spaces are always completely filled with fluid.

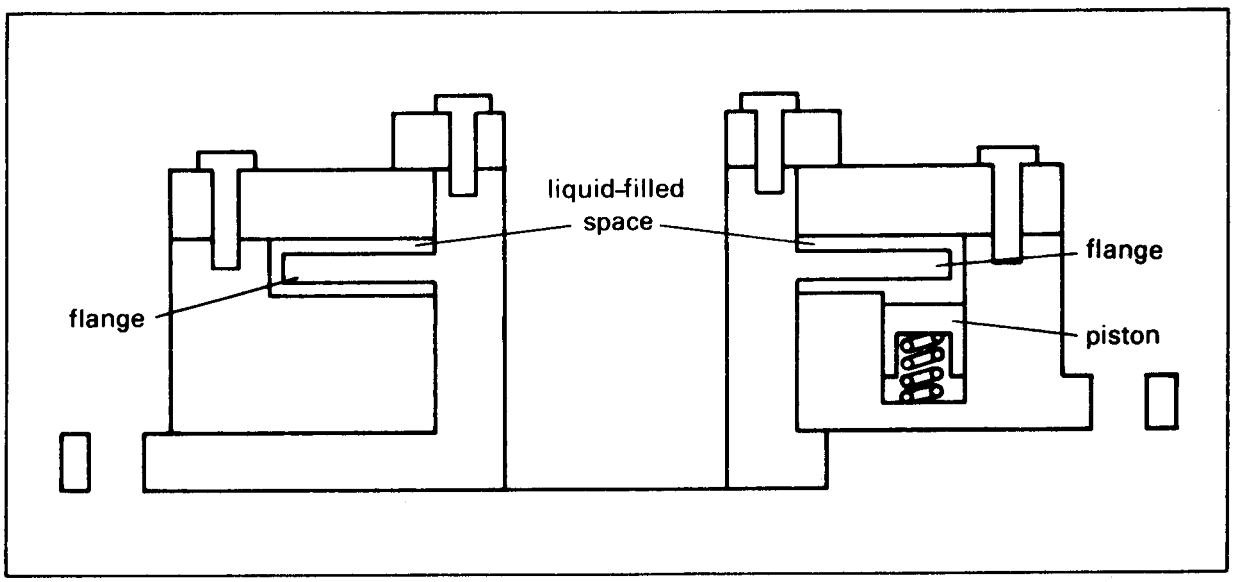

Figure 11-11. Schematic of a rotary damper.

Linear-type shear damper. A typical linear-type, shear damper consists of two telescoping tubular members that can be connected to the two objects whose movement will be restrained. (See Figure 11-12.) Between the telescoping tubes, bearing points hold a preset space to a uniform thickness. The springs at the ends of the inner tubular member provide a centering tendency that makes the damper double-acting. The spring-loaded piston keeps the space between the tubular members filled with fluid.

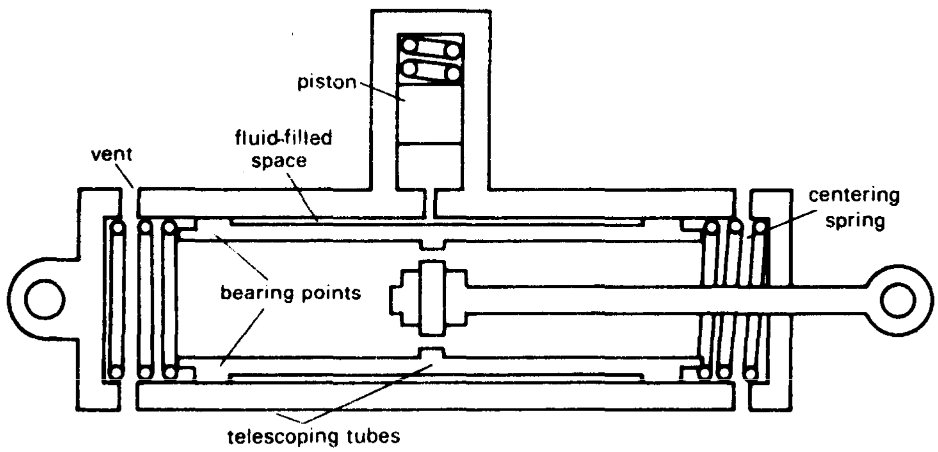

Figure 11-12. Schematic of a linear damper.

SHOCK STRUTS

Purpose. A shock strut can be thought of as a combination suspension unit and shock absorber. It performs functions in an aircraft similar to those performed in an automobile by the chassis spring and the shock absorber.

Types. The two major types of shock struts are the mechanical type and the pneudraulic type. In the mechanical type, a rubber or spring mechanism performs the cushioning operation. In the pneudraulic type, air and hydraulic fluid accomplish this. Since pneudraulic struts are the ones most commonly used in Army aircraft, they are the only type discussed in this manual. The two types of pneudraulic struts are the simple type and the complex type.

Simple Shock Struts. The basic parts of a simple shock strut are two telescoping tubes: a piston and a cylinder. A simple shock strut is installed in an aircraft with the piston uppermost and the cylinder filled with fluid. (See Figure 11-13.) An orifice in the piston head permits fluid to pass from one chamber to the other. When a shock strut has sufficient fluid above the piston head. the above above the fluid is filled with air. When the aircraft is landing and the shock strut is compressing, fluid is forced through the orifice into the piston. The movement of fluid through the orifice, together with the compression of the air, absorbs the energy of the descending aircraft's motion.

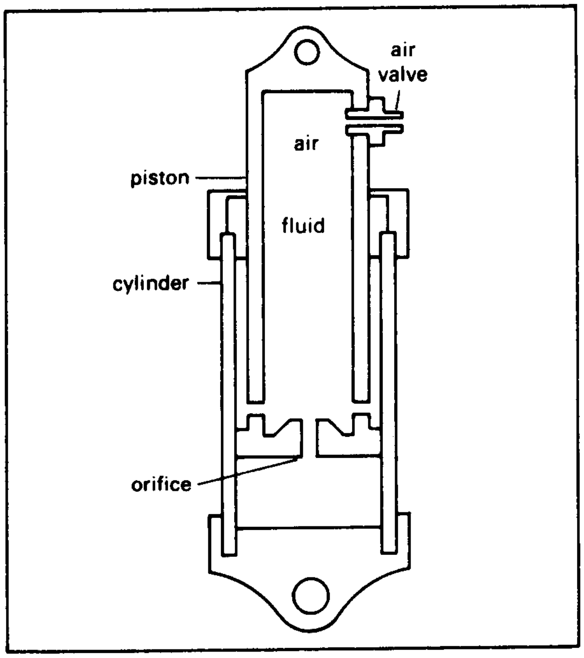

Figure 11-13. Simple shock strut (compressed).

When the load on the shock strut is lightened, the shock strut extends. (See Figure 11-14.) This extension is caused by the force exerted by the compressed air in the shock strut and, during takeoff, by the weight of the lower tube and attached landing gear. When the shock strut is extending, fluid in the piston passes through the orifice into the cylinder.

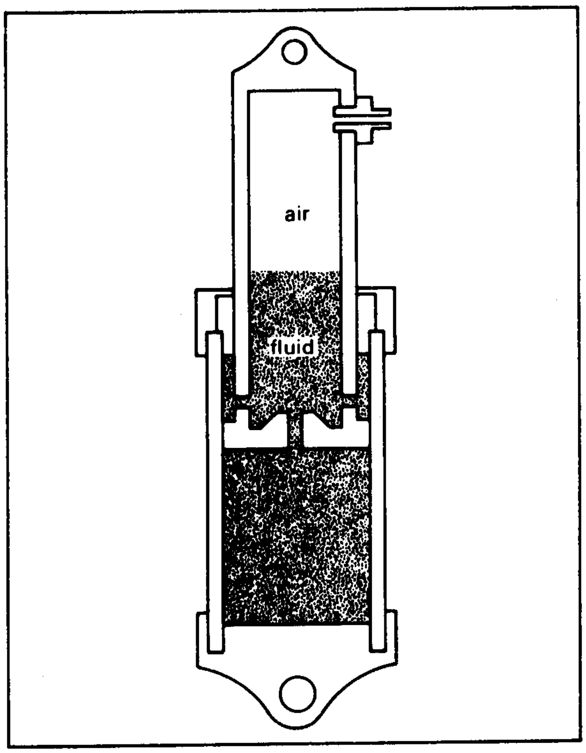

Figure 11-14. Simple shock strut (extended).

Complex Shock Struts. A complex shock strut (Figure 11-15) works in essentially the same manner as a simple one; however, it contains, besides two telescoping tubes, a number of parts that provide a more effective damping action than a simple strut. Design features found singly or in combination in complex-type shock struts are the metering pin, plunger, and floating piston.

Metering pin. The metering pin changes the effective size of the orifice to vary the rate of fluid flow from one chamber of the shock strut to the other. The diameter of the metering pin varies along its length; it is almost equal at the ends and smaller in the middle. The unanchored end of the metering pin is located in the orifice when the shock strut is fully extended. The large diameter of the pin at this end provides a high resistance to fluid flow, a condition that is required during landing. The small diameter portion of the metering pin is located within the orifice when the shock strut is in the taxi position (partially compressed). This provides the low 'resistance to fluid flow that is required for taxiing. The portion of the metering pin nearest its anchored end lies within the orifice when the shock strut is completely compressed. The large diameter of the metering pin at this end provides increased resistance to fluid flow. The design of the pin at this end ensures against bottoming of the shock strut during unusually hard landings. The gradual increase in the diameter of the pin toward the anchored end prevents a sudden change in resistance to fluid flow.

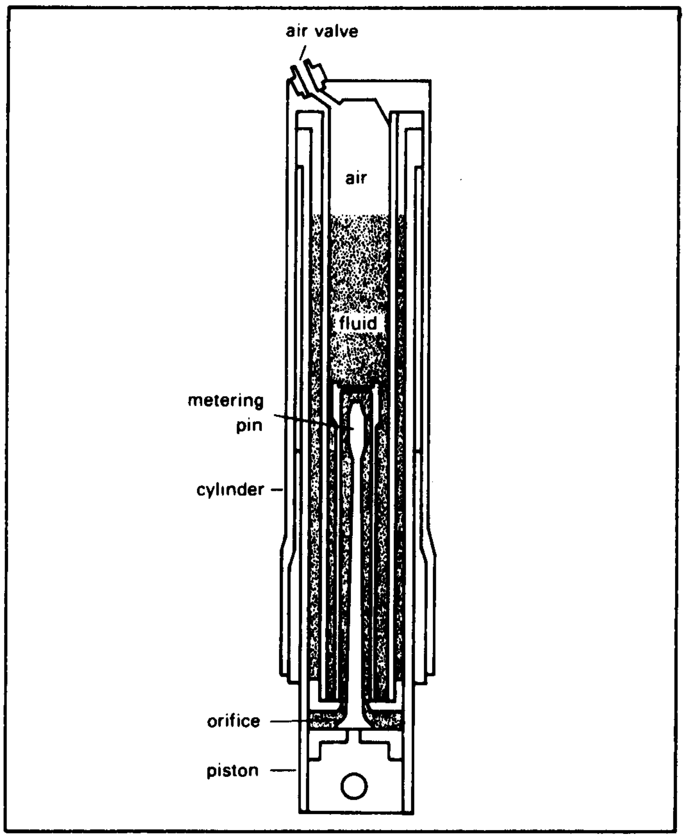

Figure 11-15. Metering pin-type complex shock strut.

Plunger. Some complex shock struts are mounted on the aircraft with their cylinders uppermost. (See Figure 11-16.) In such a unit, a plunger anchored in the cylinder extends downward into the piston. The plunger forces fluid out of the piston and into the cylinder during the shock strut compression. The plunger is hollow; fluid enters and leaves its interior through an orifice and holes in its walls.

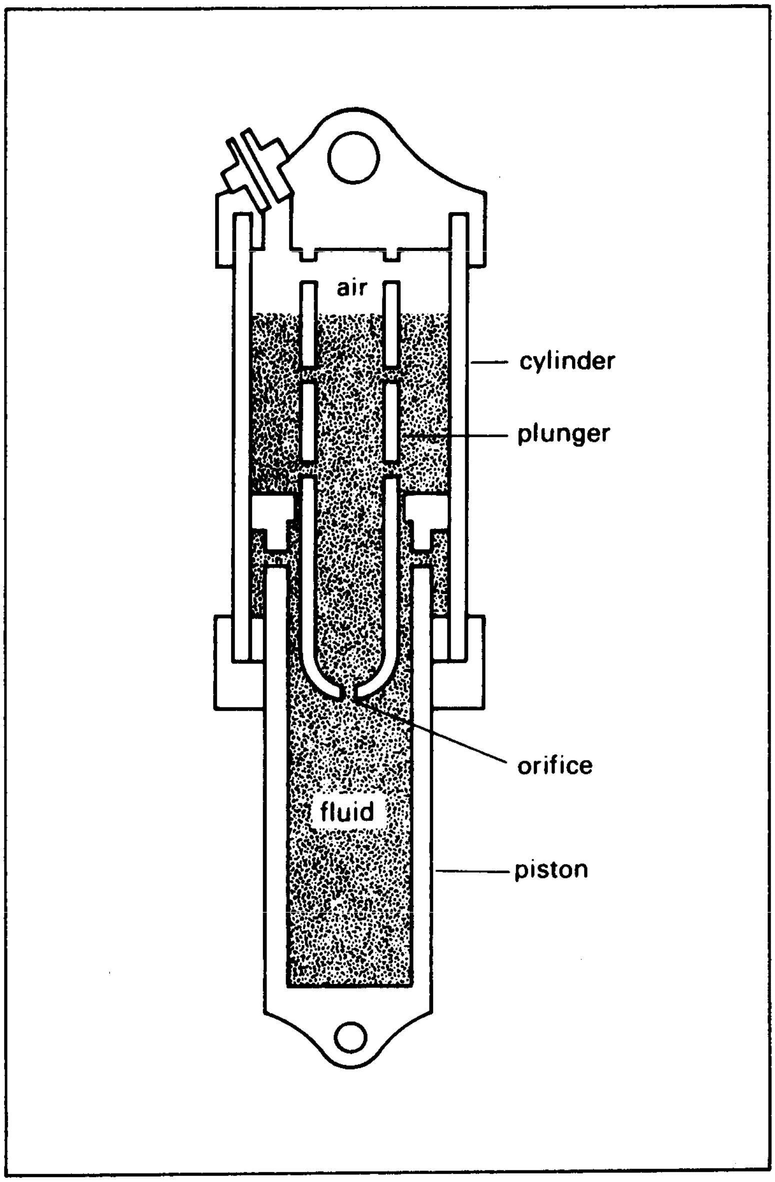

Figure 11-16. Plunger-type complex shock strut.

Floating piston. In some shock struts, the air charge is carried at the bottom of the shock strut instead of at the top. Since air normally rises to the top of a liquid, a device must be provided to keep the air below the liquid. A floating piston serves this purpose. In the floating-piston-type shock strut, the upper chamber of the strut decreases in size as the strut compresses. (See Figure 11-17.) This is because the compression forces fluid downward out of the upper chamber into the lower fluid chamber. The increase in the lower fluid chamber's size, necessary for accommodating the inflow of fluid, is obtained by the floating piston's downward movement. Besides holding the air below the fluid, the floating piston contributes to the movement of fluid through the orifice as the shock strut compresses and extends.

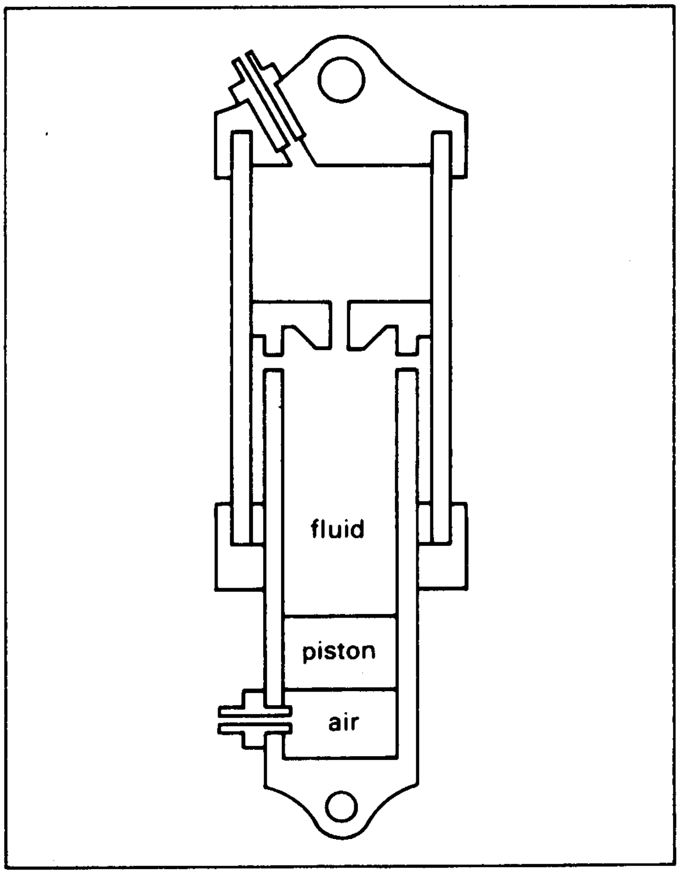

Figure 11-17. Floating-piston-type complex shock strut (compressed).

Functions. Shock struts perform three major functions. They support the static load (deadweight) of the aircraft, cushion the jolts during taxiing or towing of the aircraft, and reduce shock during landing.

Supporting Static Loads. The normal load of a parked aircraft is static, meaning the force present is fixed. The pressure of the air and fluid within a shock strut tends to keep the shock strut fully extended. However, air pressure in a shock strut is not enough to keep the strut fully extended while supporting the static load of an aircraft. Therefore, a shock strut gives under load and compresses until the air pressure builds enough to support the aircraft.

Cushioning Jolts. As an aircraft taxies, the uneven surface of the runway causes the aircraft to bob up and down as it moves forward (sometimes air currents contribute to this effect). The inertia of the aircraft fuselage in opposition to such up-and-down movement causes the force of the taxi load to fluctuate. This bouncing motion is held within limits by the damper-like action of the shock strut. This dampening results from resistance created by the back-and-forth flow of fluid through the orifice as the shock strut extends and compresses.

Reducing Shock. The aircraft will continue to descend at a high rate when landing, even after the wheels touch the ground. In the few remaining inches that the fuselage can move toward the ground after the wheels touch, the descent of the aircraft must be stopped. To do this, the shock strut must remove a great amount of energy from the downward movement of the aircraft. The impact force is very great compared to the force exerted by the mere weight of the aircraft. The shock strut removes some of the energy of motion and impact force by converting energy into heat and dissipating the heat into the atmosphere. The resistance to fluid flow offered by the orifice is the principal means of developing the heat. Also, the temperature of the air inside the strut rises as the air is compressed.

The speed of a descending aircraft while landing causes overcompression of the air in the shock strut. As a result, the air pressure is greater than that needed to support the static load of the aircraft. The excess pressure tends to extend the shock strut and bounce the aircraft back into the air. For comfort and control of the aircraft, this rebound has to be held to the lowest level possible. The most common means of counteracting rebound involves the use of a shock strut annular space. The annular space is a chamber that surrounds the polished piston surface that lies within the cylinder. The space has no definite volume; the volume depends on the amount the shock strut is extended or compressed. The annular space is at minimum size when the shock strut is completely extended and at maximum size when the strut is completely compressed. As the shock strut extends, fluid passes from the piston into the annular space. Compression of the shock strut forces fluid from the annular space back into the piston. Transfer of fluid into or out of the annular space takes place through transfer passages in the wall of the piston. The fluid moves with some resistance, which varies with the size of the transfer passages. In simple shock struts, the transfer passages are merely holes. In many complex shock struts, the passages are provided with a snubber valve or rebound control valve. Such a valve allows fluid to flow more freely into the annular space during shock strut compression than it flows out during extension.

<u>Maintenance.</u> Shock struts should be frequently checked for leakage, proper air pressure, secure attachment, and cleanliness. The exposed portion of the shock strut piston should be cleaned frequently with a clean, lint-free cloth moistened with hydraulic fluid. Specific instructions for servicing with hydraulic fluid and air pressure are stamped on the nameplate of the shock strut and are given in the applicable aircraft manual. With a few exceptions, a single port in the shock strut serves as a filler hole for both hydraulic fluid and air. An air valve assembly screws into the port.

CAUTION

ALWAYS BE SURE TO RELEASE THE AIR PRESSURE BEFORE ATTEMPTING TO REMOVE THE AIR VALVE CORE OR ASSEMBLY. ROCK THE AIRCRAFT AND DEPRESS THE VALVE CORE SEVERAL TIMES WITH A SUITABLE METAL TOOL TO ENSURE THAT ALL PRESSURE IS RELEASED. AIR PRESSURE COULD BLOW OUT THE AIR VALVE CORE OR ASSEMBLY WHEN EITHER OF THEM IS LOOSE.

LIQUID SPRINGS

Functions. The liquid spring contains hydraulic fluid under pressure. The cushioning effect of the spring is produced by a slight compression in the fluid. In Figure 11-18, note that the piston rod fits into the inner space of the cylinder.

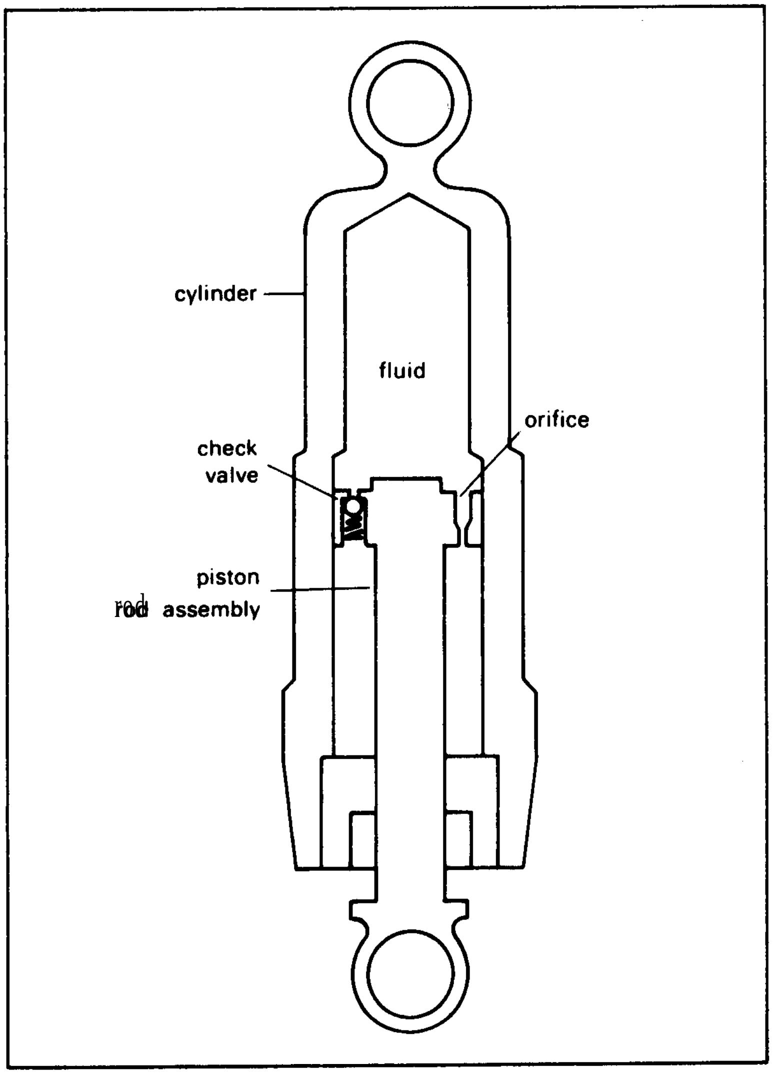

Figure 11-18. Liquid spring.

A gland seal is provided to prevent fluid leakage as the piston rod moves in and out of the housing. The housing is attached to a stationary part of the aircraft; the piston rod is connected to a movable part of the landing gear. Figure 11-19 shows a liquid spring installed on the tail landing gear of an Army aircraft.

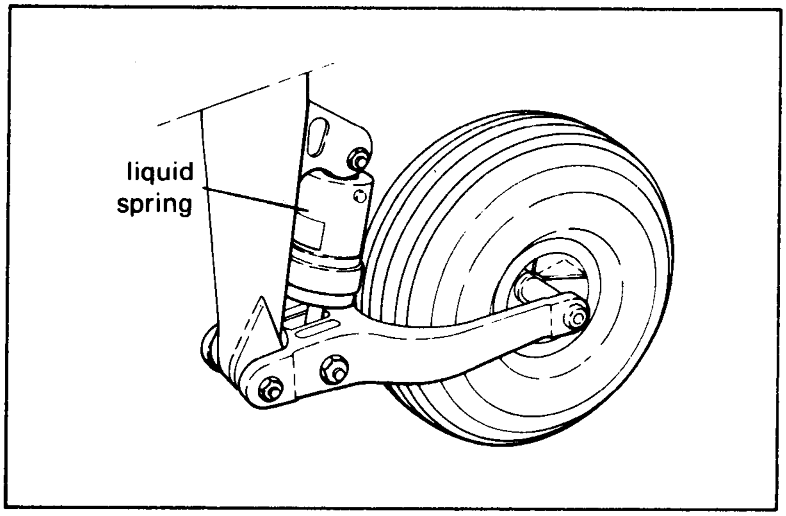

Figure 11-19. Liquid spring installed on tail landing gear.

Liquid springs support static loads of the aircraft, cushion the jolts during taxiing and towing of the aircraft, and reduce shock during landing. Liquid springs perform the same functions as shock struts, but their operations differ.

Supporting Static Loads. The weight of the parked aircraft moves the liquid spring housing downward over the piston rod. The inward movement of the piston rod decreases the space occupied by the fluid; it compresses the fluid and increases its pressure. The movement continues until fluid pressure puts a force on the shaft equal to the force that moves the shaft inward. When this force is reached, no further inward movement of the shaft takes place; the aircraft is held in a stationary position.

Cushioning Jolts. The liquid spring controls the bouncing motion of the aircraft in the same manner as shock struts. As the piston in the liquid spring moves in and out of the housing, fluid moves back and forth through an orifice in the piston. This fluid flow restrains the rate at which the piston moves and dampens the up-and-down movements of the aircraft fuselage.

Reducing Shock. In the liquid spring, the resistance to fluid flow necessary to convert motion energy to heat energy is effected by a check valve in the piston. As the liquid spring compresses, fluid flows through the check valve and orifice. During extension of the liquid spring, the check valve closes, and fluid then passes through the orifice only. The additional restraint that is set up to the movement of fluid from one side of the piston to the other provides rebound control during landing.

Maintenance. The exposed portion of the liquid spring shaft should be cleaned with a clean, lint-free cloth moistened with hydraulic fluid. When the liquid spring is filled to the correct level with the proper type of hydraulic fluid, the fluid will be under pressure. A special gun which looks like a hand-grease gun is used to force the fluid inside the spring. Specific servicing instructions are stamped on the nameplate of the spring and are given in the applicable manual for the aircraft.